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What do you think?

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Problems and solution

Due to the deficiency of current hemostatic methods, a new technology is desired to be invented. In this article, I will introduce the biological mechanism of a synthetic material, PolySTAT, which helps blood clot. I choose this topic because I have always wanted to be a medical field worker. Additionally, it may save many people’s life from hemorrhage. PolySTAT is a brand-new technology with wide-ranging therapeutic application. Also, it eliminates the deficiency of some current hemostatic approaches. As its creators say, “PolySTAT is hardier both inside and outside the body.” PolySTAT is a novel technology with promising future. However, till now it has only been tested on rats. Clearly, there are great demands of hemostats in the society. Therefore, more experiments should be done to carry out this technology, and apply PolySTAT in our daily life.

Mechanism of PolySTAT & evaluation

Current methods & deficiencies

There are some well-established first-aid approaches to stop bleeding. The easiest way to do so is by applying pressure on the wound. The pressure makes it harder for blood to bleed out. Meanwhile, the blood begins to clot. However, when it comes to internal bleeding, like organ damage, applying pressure is not enough to stop ecchymosis inside our body.

FIGURE 1 [1]

Combat Application Tourniquet

Combat Application Tourniquet is effective towards limbs wound. However, it becomes useless when a chest wound occurs. Combat Application Tourniquet (CAT) is widely used in the U.S. military as a first aid kit [1]. A CAT is really useful dealing with limbs shots. However, when it comes to chest wound or internal bleeding, there is nothing a tourniquet can do for the casualty. Blood transfusion is another approach to resolve hemorrhage. Although it is a quite effective approach to rescue hemostatic function, it is rather expensive and inappropriate for portable purpose, since it requires frozen preservation.

Mechanism of clotting

Our blood consists of red blood cells that carry oxygen particles, platelets that come from white blood cells’ fragments, and clotting factors that help blood clot [2]. When a blood vessel is damaged, platelets immediately stick to the edges of the cut and release chemicals that attract more platelets. Eventually, a platelet plug is formed and the outside bleeding stops. On the inside, clotting factors cause a cascade of activity that includes strands of blood-borne material called fibrin, sticking together to seal the inside of the wound [2]. Eventually, the blood vessel heals and several days later, the blood clot dissolves [2].

Mechanism of PolySTAT

At University of Washington, researchers have created a synthetic material, PolySTAT that is injectable to help fortify the fibrin network, and thus stop the bleeding. The researchers found out that blood clotted much more quickly with the material PolySTAT. Fibrin, as mentioned, plays a very important role of reinforcing clots by creating a robust fibrin network. However, the decline of fibrinogen concentration results from rapid depletion of blood will prevent the formation of a strong and robust network of fibrin [3]. The resulting clots are therefore weak and insufficient to stop the bleeding [3]. In our body, there is a clotting factor XIII (FXIII) which has been shown to produce fibrin networks with thinner fiber diameters, greater fiber density, and smaller pores for a given fibrinogen concentration. The synthetic material, PolySTAT mimics the role of FXIII, and stabilizes blood clots through fibrin cross-linking [3].
Three reasons why it is more effective?

Firstly, it helps create a stiffer and robust fibrin network. The technology, fibrin cross-linking is a novel approach to resolve hemorrhage by enhancing fibrin network around the wound. The architectural changes that has been brought by PolySTAT really make a difference in improving clot stiffness and resistance to fibrinolysis.

Secondly, PolySTAT is still handy in the condition of serious hemorrhage. Fibrin, which is a strand of blood-borne material helps clot, and therefore stops the bleeding. However, the formation of a strong fibrin network depends on the fibrinogen concentration in our blood. When a serious hemorrhage occurs, fibrinogen concentration declines with the loss of blood. According to the article, “Mortality is markedly increased in trauma patients when fibrinogen concentrations fall below a critical threshold of 2.29 mg/ml” [3]. In the experiment, researchers created three different conditions, above threshold, average concentration, and below threshold (3.0, 2.2, 1.5 mg/ml, respectively) [3]. Then they injected PolySTAT (5µM) to determine whether clot strength could be rescued through PolySTAT [3]. From the resulting statistic, we can see that PolySTAT is still effective helping clot under serious condition.

Lastly, compared to some nanoparticle technology, its delayed clot breakdown is the third reason why it is more effective. “So far, several synthetic platelets, like nanoparticle poly(lactic-co-glycolic acid)-poly-L-lysine-poly(ethylene glycol)-[Arg-Gly-Asp] (PLGA-PLL-PEG-RGD) have been reported to induce faster blood clotting after intravenous injection” [3]. “However, a challenge with nanoparticle based approaches is their rapid clearance by the reticuloendothelial system (RES)” [3].

My evaluation towards PolySTAT

I think PolySTAT is important to me because it can prevent my friends’ deaths. I am in Reserve Officer Training Corps (ROTC) program, and I have made several really good friends. We exercise together in the morning, and go to classes in groups. It is quite hard to believe that in 4 years,
some of them are going to be deployed in places like Iraq and Afghanistan, where they may be shot in the battlefield. Another reason why I choose this technology is that I have always want to be a medical field worker under my mom's influence.

Once applied, PolySTAT can really make a difference. For one thing, it can change the perspective and convention of battlefield casualty care. Last Saturday, I went to ROTC lab at Boyce Park regarding combat casualty care. I learned from sergeant Chisholm that at present, applying a tourniquet is the principle method to stop bleeding in the battlefield. However, a tourniquet can only be applied at our limbs. In some cases, like wound chest, there is not much a medic can do for the casualty. Additionally, the casualty may suffer internal bleeding, like organ damage, which can become the grim reaper if there is no solution towards this problem. Fortunately, a technology like PolySTAT which is able to stop external as well as internal bleeding will really make a difference.

Why it is important to engineering?

Engineering has always had an intimate relationship with military, for example medical equipment, and vehicle repair. PolySTAT is important to engineering because there is an urgent demand in the U.S. military. Also, because PolySTAT is still in the phase of development, there are many things need to be considered, for example the preservation. One of its creators says that “This is something you could potentially put in a syringe inside a backpack and give right away to reduce blood loss and keep people alive long enough to make it medical care.” Nevertheless, new preservation technology may still need to be invented. Although as it creators say, is harder both inside and outside the body, there are further experiments to be done and tested in larger models. Further preclinical studies still will be needed in order to carry out this technology, and apply to our daily life.

Conclusion

Due to the deficiency of current methods of treating hemorrhage, a novel and efficient way is desired to resolve the problem. Deficiencies like potential danger of contaminated blood source used for transfusion, uncompressed distant vessels hidden inside of our body, and limited usage of existing equipment like tourniquet may cause undesired death of hemorrhage. Through intravenous injection, PolySTAT is able to reach distant impaired arteries and then stop the bleeding by creating a strong and robust fibrin network. Thus, it greatly decreases the possibilities of casualties’ death on the way to hospitals.

For me, this novel technology has a wide-ranging therapeutic application. Once applied in real life, this technology definitely will make a difference. Firstly, it eliminates the limit of combat tourniquet. Besides battlefield application, this technology can also be applied in hospitals and even in daily life.

PolySTAT is important to me because I am in the military, and there is a huge possibility that I or my friends may be shot in the battlefield. Especially after the casualty care lecture from last Saturday lab, I learned that there is an urgent demand towards hemostasis in the U.S. army. Engineering has always had an intimate relationship with military. It is important to engineering because it is still in the phase of development with wide-ranging therapeutic application. Thus, it needs further research and experiments to make it truly portable and easy to use.

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ACKNOWLEDGMENTS

I am very grateful that Three River Battalion provides me with the opportunity to receive hands-on experience about battlefield casualty first aid and amazing lectures. Also, I appreciate the writing instruction that Katie Homar and Katherine Kidd gave me regarding engineering writing assignment #3.